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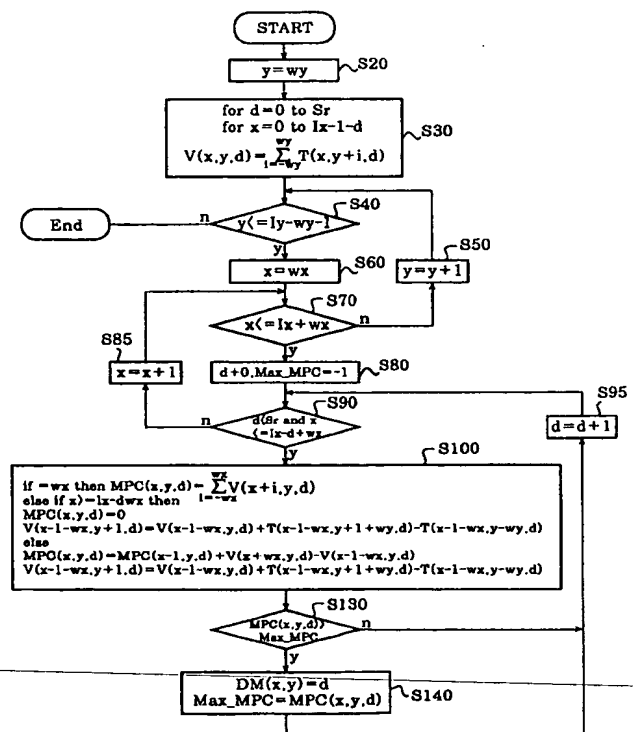
Published

Without international search report and to be republished upon receipt of that report.

(54) Title: METHOD AND APPARATUS FOR MEASURING SIMILARITY USING MATCHING PIXEL COUNT

(57) Abstract

A stereo disparity between a reference image and a search image for a reference pixel in the reference image is determined by (a) calculating a similarity measure between a reference window including a set of pixels centering on the reference pixel and each of a group of search windows in the search image which is of a same shape with the reference window and displaced from the reference window within a predetermined search range, wherein a matching pixel count, which is the number of pixels in the reference window which are similar in intensity to corresponding pixels in a search window, is used as the similarity measure between the reference window and the search window; and (b) determining a displacement between the reference window and a search window which yields a largest similarity measure as the stereo disparity for the reference pixel.



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INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 99/00174

A. CLASSIFICATION OF SUBJECT MATTER

IPC⁷: G 06 T 17/00; H 04 N 13/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁷: G 01 B; G 02 B; G 06 F; G 06 T; H 04 N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PAJ, WPI, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 4444697 A (Bodenseewerk Geraetetechnik) 20 June 1996 (20.06.96), claims 1-4; abstract.	1-13
A	JP 09-204524 A (Toshiba KK) 05 August 1997 (05.08.97) (abstract). [online]. Retrieved from: EPO PAJ Database.	1-13

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

„A“ document defining the general state of the art which is not considered to be of particular relevance

„E“ earlier application or patent but published on or after the international filing date

„L“ document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

„O“ document referring to an oral disclosure, use, exhibition or other means

„P“ document published prior to the international filing date but later than the priority date claimed

„T“ later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

„X“ document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

„Y“ document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

„&“ document member of the same patent family

Date of the actual completion of the international search

29 June 2000 (29.06.00)

Date of mailing of the international search report

18 July 2000 (18.07.00)

Name and mailing address of the ISA/AT

Austrian Patent Office
Kohlmarkt 8-10; A-1014 Vienna
Facsimile No. 1/53424/200

Authorized officer

Werner

Telephone No. 1/53424/357

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR 99/00174

Patent document cited in search report			Publication date	Patent family member(s)	Publication date
DE	A1	4444697	20-06-1996	none	
JP	A2	9204524	05-08-1997	none	

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PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference KIST 98678	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/KR 99/00174	International filing date (day/month/year) 13 April 1999 (13.04.99)	Priority Date (day/month/year) 13 April 1998 (13.04.98)
International Patent Classification (IPC) or national classification and IPC IPC⁶: G 06 T 17/00; H 04 N 13/00		
Applicant KOREA INSTITUTE OF SCIENCE AND TECHNOLOGY		

1. This international preliminary examination report has been prepared by this International Preliminary Examination Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of <u>3</u> sheets, including this cover sheet. <input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT). These annexes consist of a total of <u>9</u> sheets.
3. This report contains indications relating to the following items: I <input checked="" type="checkbox"/> Basis of the report II <input type="checkbox"/> Priority III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability IV <input type="checkbox"/> Lack of unity of invention V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement VI <input type="checkbox"/> Certain documents cited VII <input type="checkbox"/> Certain defects in the international application VIII <input type="checkbox"/> Certain observations on the international application

Date of submission of the demand 25 October 1999 (25.10.99)	Date of completion of this report 04 July 2000 (04.07.00)
Name and mailing address of the IPEA/AT Austrian Patent Office Kohlmarkt 8-10 A-1014 Vienna Facsimile No. 1/53424/200	Authorized officer Werner
	Telephone No. 1/53424/357

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/KR 99/00174

I. Basis of the report

1. With regard to the elements of the international application:*

- ☐ the international application as originally filed
- ☒ the description:
 pages 1-4,6-8,10-17, as originally filed
 pages 5,9, filed with the demand
 pages _____, filed with the letter of 25 October 1999 (25.10.99)
- ☒ the claims:
 pages 18-23 (claims 1-13), as originally filed
 pages _____, as amended (together with any statement) under Article 19
 pages _____, filed with the demand
 pages _____, filed with the letter of _____
- ☒ the drawings:
 pages 1-3,7,9,10,12, as originally filed
 pages 4,5,6,8,11,13,14, filed with the demand
 pages _____, filed with the letter of 25 October 1999 (25.10.99)
- ☐ the sequence listing part of the description:
 pages _____, as originally filed
 pages _____, filed with the demand
 pages _____, filed with the letter of _____

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item. These elements were available or furnished to this Authority in the following language _____ which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as „originally filed“ and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/KR 99/00174

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	<u>1-13</u>	YES
	Claims	_____	NO
Inventive step (IS)	Claims	<u>1-13</u>	YES
	Claims	_____	NO
Industrial applicability (IA)	Claims	<u>1-13</u>	YES
	Claims	_____	NO

2. Citations and explanations (Rule 70.7)

The documents cited in the search report disclose methods for the estimation of stereo disparity and parallax effects respectively used in stereo image processing.

However the idea of employing a matching pixel count as a similarity measure between reference image and search image is not disclosed in the cited prior art.

The subject-matter of claim 1 as well as of dependent claims 2-13 appears therefore novel over prior art.
There is a sufficient inventive step involved.
Industrial applicability is obviously given.

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45. 11. 1999

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Figure 1 illustrates matching subject to an epipolar constraint.

Figure 2 illustrates the comparative performance of the SAD and MPC similarity measures.

5 Figures 3A and 3B illustrate redundant operations involved in determining the MPC similarity measure.

Figures 4A and 4B illustrate a method of determining the MPC similarity measure from which redundant operations have been eliminated.

10 Figure 5 is a flow chart for determining the MPC similarity measure in accordance with an embodiment of the present invention.

Figure 6 shows an apparatus for determining a disparity map $D(x,y)$ in accordance with an embodiment of the present invention.

15 Figure 7A illustrates the internal structure of the P-buffer of the apparatus shown in Figure 6.

Figure 7B illustrates the internal structure of the V-buffer of the apparatus shown in Figure 6.

20 Figure 8A illustrates the internal structure of the P-unit of the apparatus shown in Figure 6

Figure 8B is a circuit diagram of the D_P unit of the P-unit illustrated in Figure 8A.

25 Figure 9 illustrates the internal structure of one of the MPC-units of the apparatus shown in Figure 6.

Figure 10 is a logic diagram of the MPC-unit whose internal structure is illustrated in Figure 9.

Figure 11 illustrates the internal structure of the Max_MPC selector of the apparatus shown in Figure 6.

30 Figure 12 is a logic diagram of the C&A(n) cell of the apparatus shown in Figure 11.

Best Mode for Carrying out the Invention:

35 In the method described and claimed in the present application, a matching pixel count ("MPC") is used as a measure of the similarity between a reference window in a reference image and each of a plurality of search windows in a search image. The contribution of a given matching pixel in

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reference image are shown. $V(x, y, d)$ represents a matching pixel count between two vertical segments which are a group of W_y pixels centered at $R(x, y)$ and $L(x+d, y)$. $MPC(wx, y, d)$ is computed by summing V values as follows:

$$MPC(wx, y, d) = \sum_{i=-wy}^{wy} V(wx+i, y, d) \quad (2)$$

For x larger than w_x , $MPC(x, y, d)$ can be computed from a previously computed MPC value (i.e., $MPC(x-1, y, d)$) as follows:

$$MPC(x, y, d) = MPC(x-1, y, d) + V(x+w_x, y, d) - V(x-1-w_x, y, d) \quad (3)$$

In Equations (2) and (3), w_x and w_y denote distances from the center to the boundary of a window in the horizontal and vertical directions, respectively:

$$w_x = (W_x - 1) / 2 \text{ and } w_y = (W_y - 1) / 2 \quad (4)$$

In a similar manner, a first V value in a column, $V(x, w_y, d)$, is computed by summing $P(\cdot)$ for a vertical segment:

$$V(x, w_y, d) = \sum_{i=-wy}^{wy} p(x, w_y+i, d) \quad (5)$$

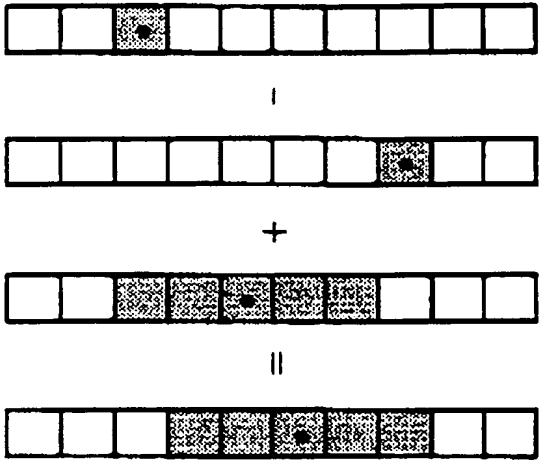
where $P(x, y, d)$ has the value one if values of $R(x, y)$ and $L(x+d, y)$ are similar and has the value zero otherwise as defined in Equation. (1). For values of y greater than w_y , $V(x, y, d)$ can be computed by using a previously computed V value, $V(x, y-1, d)$:

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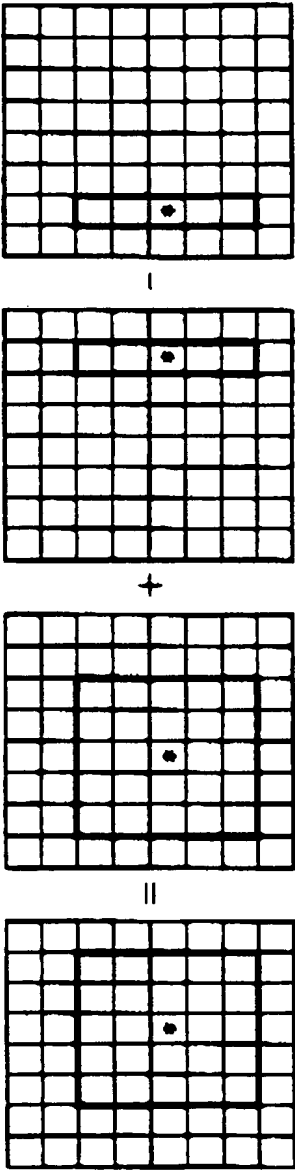
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Fig. 4a



$$V(x,y,d) = V(x,y-1,d) + T(x,y+wy,d) - T(x,y-1-wy,d)$$

Fig. 4b



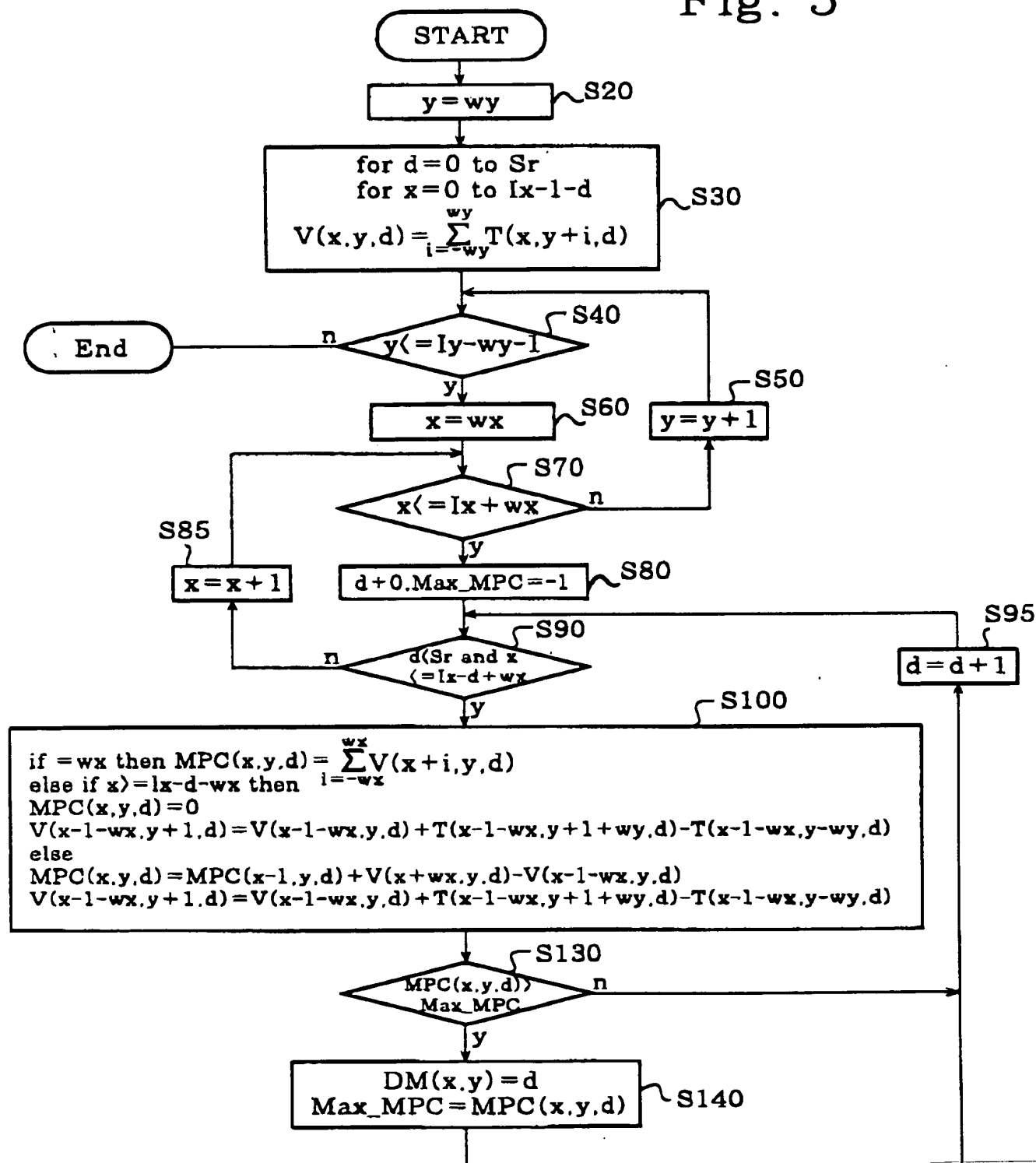
$$MPC(x,y,d) = MPC(x-1,y,d) + V(x+wx,y,d) - V(x-wx-1,y,d)$$

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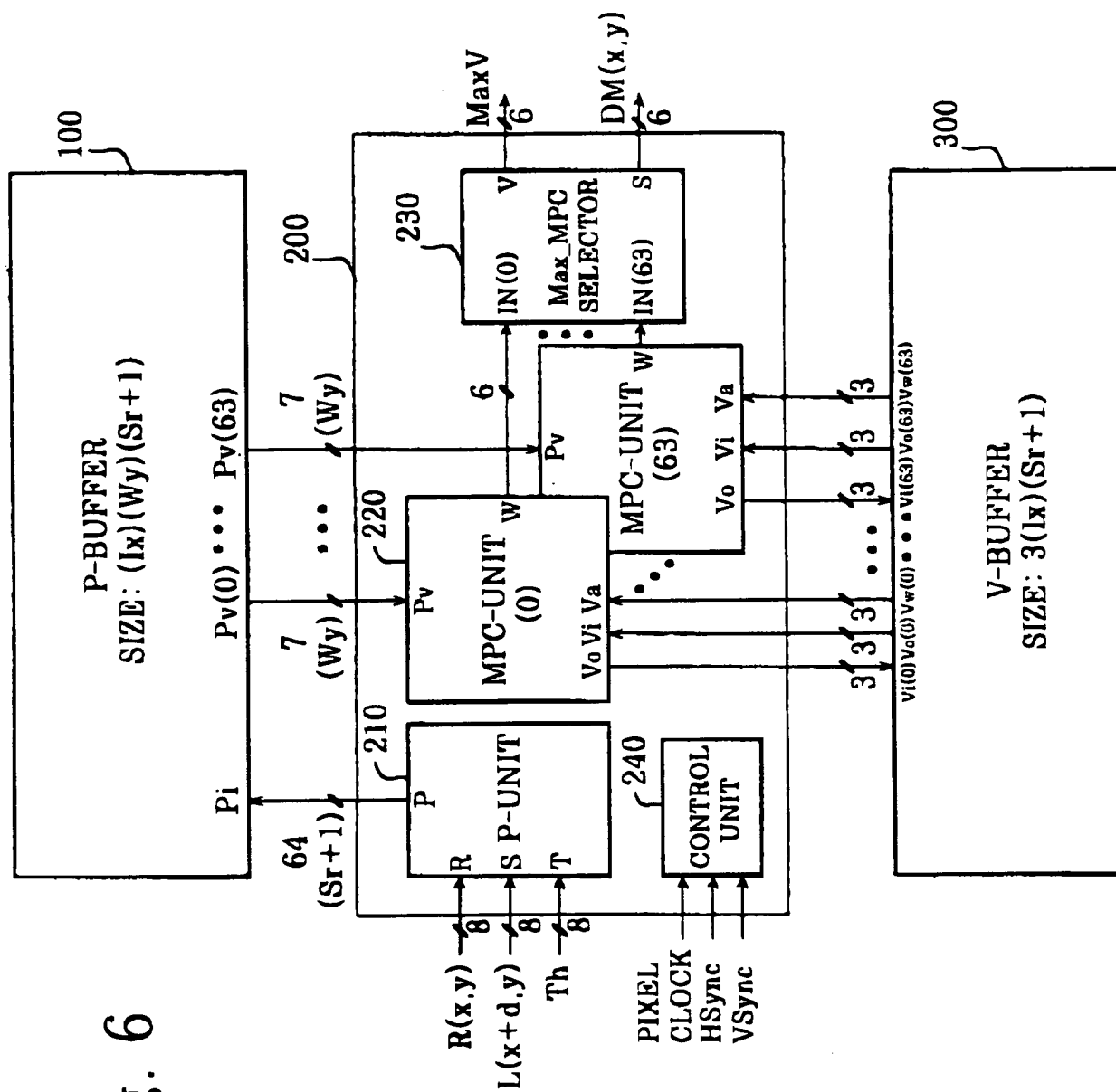
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Fig. 5



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Fig. 6

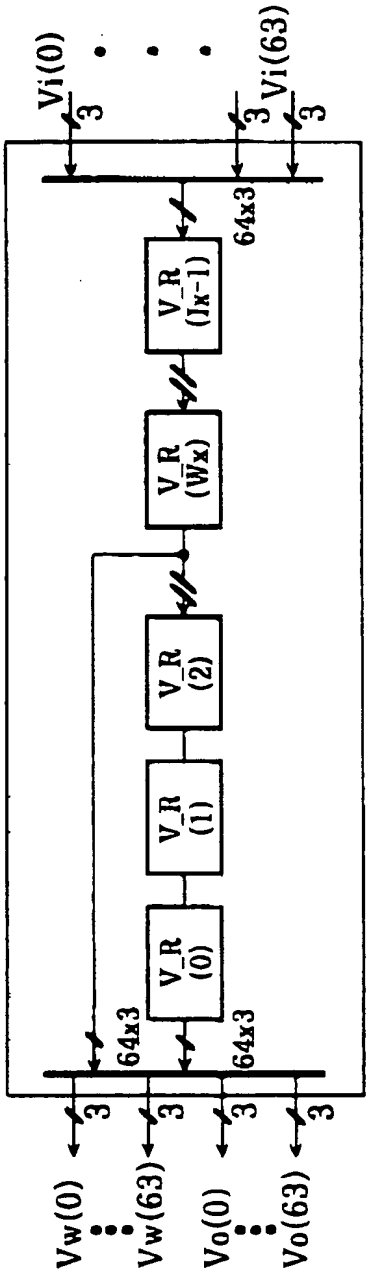


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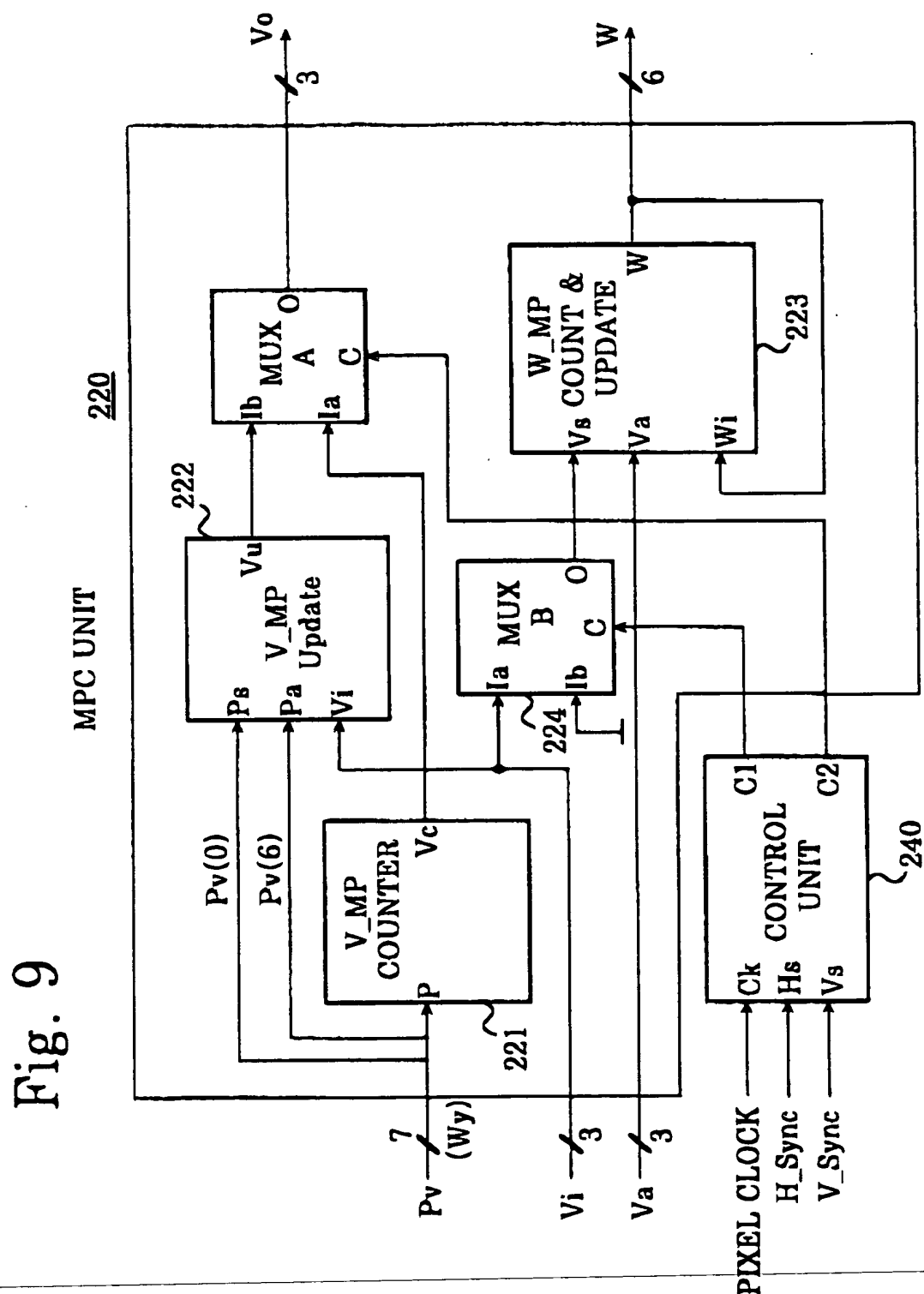
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Fig. 7b

V-BUFFER
300



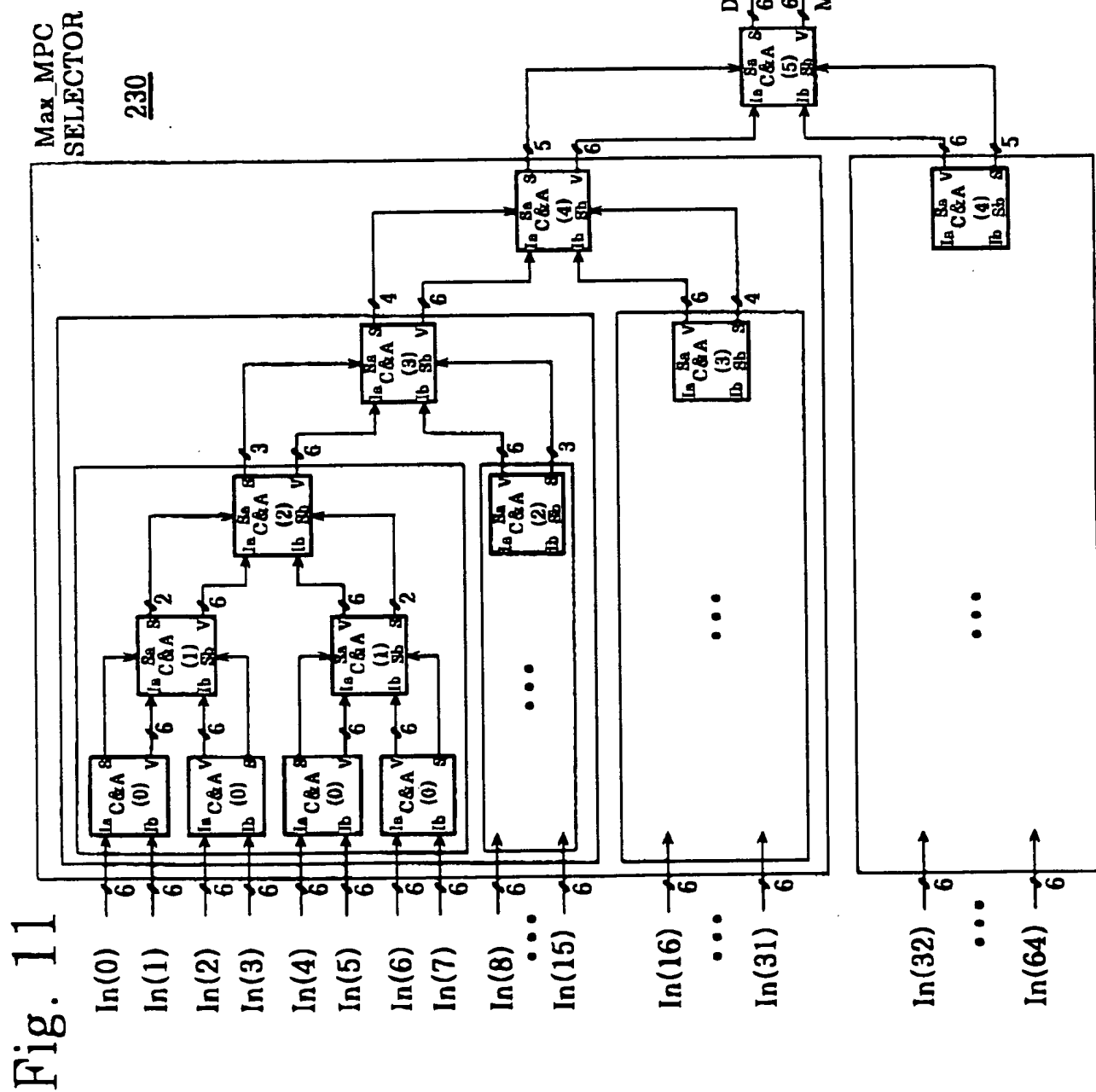
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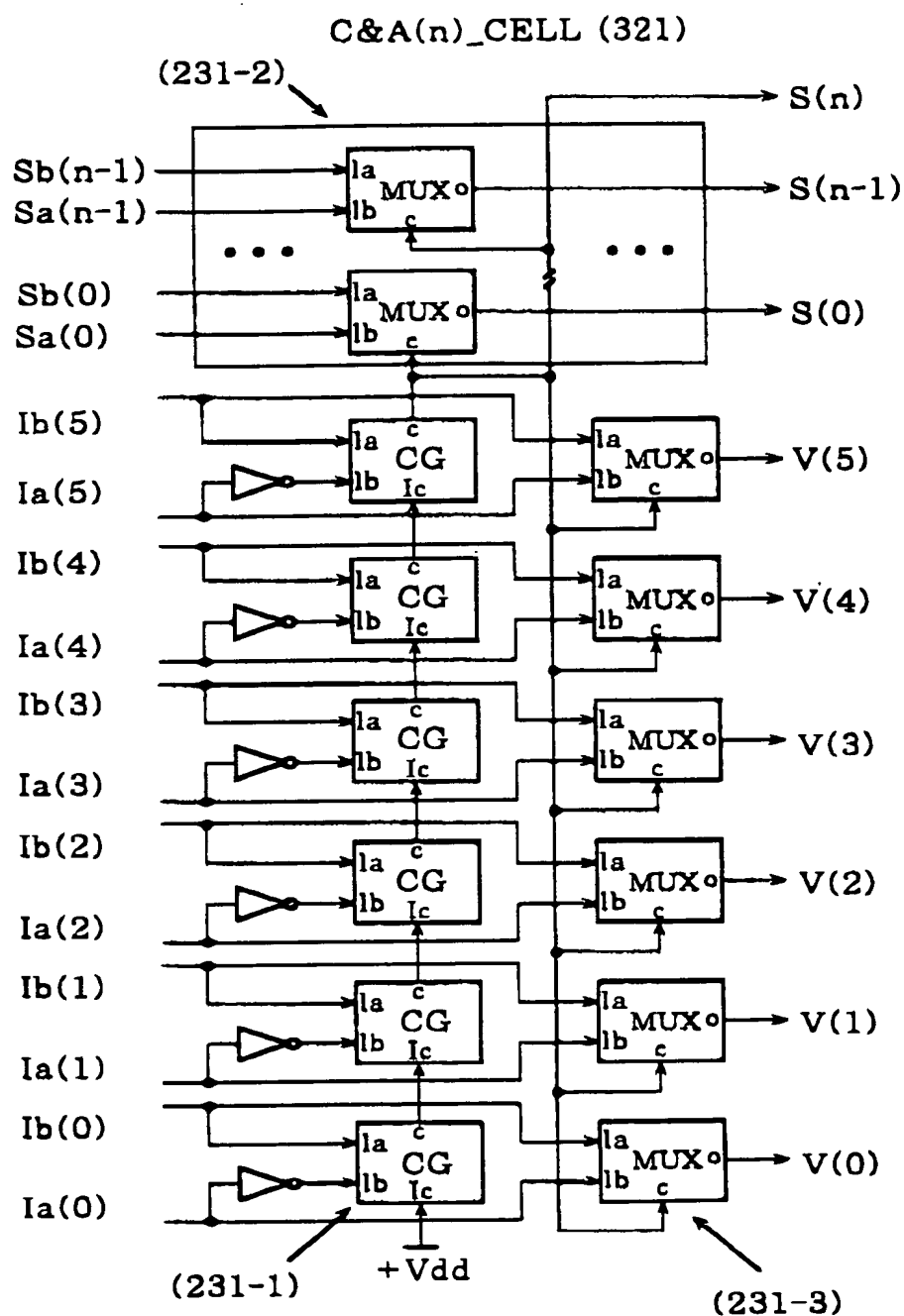
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Fig. 12



PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

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in its capacity as elected Office

Date of mailing (day/month/year)

19 November 1999 (19.11.99)

International application No.

PCT/KR99/00174

Applicant's or agent's file reference

KIST 98678

International filing date (day/month/year)

13 April 1999 (13.04.99)

Priority date (day/month/year)

13 April 1998 (13.04.98)

Applicant

KIM, Hyoung, Gon et al

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

25 October 1999 (25.10.99)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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Authorized officer

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